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UNITED STATES DEPARTMENT OF AGRICULTURE

BULLETIN No. 297

Contribution from the Bureau of Plant Industry
WM. A. TAYLOR, Chief

Washington, D. C. ▼ October 28, 1915

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CEREAL INVESTIGATIONS ON THE BELLE FOURCHE EXPERIMENT FARM

By

CECIL SALMON, formerly Plant Physiologist,
Office of Cereal Investigations

CONTENTS

	Page.		Page.
Introduction	1	Experiments with Oats	29
Description of the Field Station	2	Experiments with Barley	34
Experimental Methods	10	Experiments with Minor Cereals	38
Interpretation of Experimental Results	13	Experiments with Flax	39
Experiments with Wheat	14	Summary	40

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Experiments with wheat	14	Summary	40

INTRODUCTION.

The experiments with cereals at the Belle Fourche Experiment Farm, near Newell, S. Dak., have been conducted for the following purposes: (1) To determine the best crops, varieties, and races for that section; (2) to improve the better varieties by selective breeding; (3) to determine the best methods of cereal production; and (4) to correlate differences in production with climatic and soil conditions in order to determine the principles upon which the best practices are based. The results of these investigations have been reported in part in two previous publications.[2] The present bulletin is intended to bring the work up to date and to include results that for various reasons have not heretofore been given.

[1] The experiments here reported were conducted on the dry-farmed portion of the Belle Fourche Experiment Farm, near Newell, S. Dak. This farm, which is located on the Belle Fourche Reclamation Project, is operated by the Office of Western Irrigation Agriculture of the Bureau of Plant Industry. The experiments were conducted by the Office of Cereal Investigations in cooperation with the Office of Western Irrigation Agriculture. On April 1, 1912, the cooperative agreement between the Office of Cereal Investigations and the South Dakota Agricultural Experiment Station was expanded to include the work at Newell. The writer was in charge of the cereal work on the farm from its beginning (1907) until September 30, 1913, when he resigned to accept another position. He therefore has personal knowledge of all the experiments here reported.

[2] Salmon, Cecil. Dry-land grains for western North and South Dakota. U. S. Dept. Agr., Bur. Plant Indus. Circ. 59, 24 p., 1 fig., 1910.

——— Winter wheat in western South Dakota. U. S. Dept. Agr., Bur. Plant Indus. Circ. 79, 10 p., 1911.

The results of the experiments for six years (1908–1913) are here reported. So short a period is entirely inadequate to settle many of the problems of dry-land grain production. However, a presentation of the results obtained should be of assistance to those engaged in similar work.

DESCRIPTION OF THE FIELD STATION.

It is believed that the results here reported are applicable in general to western South Dakota, northeastern Wyoming, and southeastern Montana. The variations in soil and climate within this section, however, are considerable. To determine just how far the results obtained at Newell are applicable to any other locality, a comparison of soil and climatic conditions is necessary. In order to permit such a comparison, a description of the field station is here given, together with detailed information regarding the temperature and the amount and distribution of the rainfall during the period covered by the experiments.

LOCATION.

The Belle Fourche Experiment Farm is located near the center of the Belle Fourche Reclamation Project, in western South Dakota. The farm is about 24 miles northeast of Bellefourche and 2 miles northwest of Newell. The latitude is about 44° 43′ 45″ N. and the longitude 103° 26′ 15″ W. The elevation is approximately 2,950 feet. About one-half of the farm is irrigated. The portion which is above the irrigation ditch is used for dry-land experiments, including those here reported. The topography of the farm and of the surrounding country is rolling, affording good drainage at all times.

GENERAL PHYSICAL FACTORS.

A study of the crop yields for the series of years here presented may be made more intelligently if combined with a knowledge of the factors which have influenced crop growth. The most important physical factors are (1) the soil, (2) the rainfall and its distribution, and (3) the temperature, especially the length of the growing season as limited by spring and fall frosts. These and other physical data for the Belle Fourche farm are summarized in the paragraphs which follow.

SOIL.

The soil of the Belle Fourche farm and surrounding area is mapped as Pierre clay by the Bureau of Soils.[1] To stockmen and farmers it is familiarly known as gumbo. Table I shows the results of a mechanical analysis of Pierre clay. Its characteristic stickiness is perhaps

[1] Strahorn, A. T., and Mann, C. W. Soil survey of the Belle Fourche area, South Dakota. *In* U. S. Dept. Agr., Bur. Soils Field Oper., 9th Rept., 1907, p. 888. 1909.

explained by the large percentage of clay and silt it contains, these amounting to 35 and 43.2 per cent, respectively.

TABLE I.—*Composition of Pierre clay, as determined by mechanical analysis.*

	Per cent.
Fine gravel	0.2
Coarse sand	1.1
Medium sand	1.4
Fine sand	5.5
Very fine sand	13.0
Silt	43.2
Clay	35.0

The soil is a very heavy, stiff, impervious residual clay. It is somewhat deficient in humus, but is probably well supplied with the mineral elements of plant food. The imperviousness of the soil and the topography of the country cause considerable loss of water by run-off during heavy rains.

Plowing is difficult and expensive. Other necessary field operations, such as disking, harrowing, etc., are accomplished without difficulty. If these operations are performed at favorable times, the soil is easily put in excellent condition.

There is considerable variation in the soil on the experiment farm, even within the limits of a single field. As a general rule, the higher land is lighter in texture, better supplied with humus, and more productive. The lower land is heavier, more impervious to water, contains less humus, and is more difficult to work and to get into condition for cropping.

NATIVE VEGETATION.

The native vegetation of the locality consists largely of western wheat-grass (*Agropyron smithii*, *A. occidentale*) and buffalo grass (*Bulbilis dactyloides*). Grama grass (*Bouteloua oligostachya*) and needle grass (*Stipa comata*) are frequently found. Buffalo grass usually occupies the higher and lighter soils, especially where Pierre clay is the soil type. Western wheat-grass is confined mostly to the lower slopes and bottoms. On bottom lands subject to overflow this grass produces considerable hay of excellent quality.

Weeds, such as sunflower (*Helianthus petiolaris*), gum weed (*Grindelia squarrosa*), goosefoot (*Atriplex volutans*), and wild parsley (*Peucedanum foeniculaceum*), are plentiful. They are particularly abundant following extremely dry seasons, when the grass may be so injured that weeds are practically the only vegetation. Marsh elder (*Iva axillaris*) is of considerable economic importance because of the difficulty of eradicating it in cultivated fields. This plant commonly is called gumbo weed in this locality because it is found usually on the more impervious soils of the Pierre-clay type.

PRECIPITATION.

The climate of western South Dakota is fairly typical of that of the semiarid Great Plains, which extend from western Texas into the prairie provinces of western Canada. The precipitation decreases steadily from the eastern border of the State to the western, being least in the northwest corner.

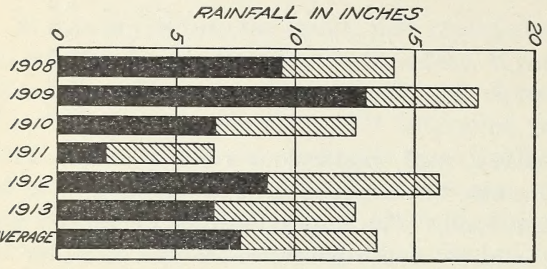

FIG. 1.—Diagram showing the annual and seasonal precipitation at the Belle Fourche Experiment Farm, for six years, 1908 to 1913, inclusive. Solid bars show the seasonal precipitation, while the total length of the bars shows the annual precipitation.

The Black Hills modify the climate of the immediately surrounding country to a great extent, mainly by increasing the precipitation. This effect extends several miles beyond the outlying foothills. The Belle Fourche farm is situated about 30 miles from the foothills and, so far as known, is not influenced to any extent by proximity to the Black Hills. The annual and average precipitation by months at the Belle Fourche Experiment Farm for the six years from 1908 to 1913 is given in Table II. Except as noted, these data were recorded at the station. The annual and seasonal rainfall is shown graphically in figure 1.

TABLE II.—*Monthly, seasonal, and annual precipitation at the Belle Fourche Experiment Farm for the six years from 1908 to 1913, inclusive.*

[Data (in inches) from the records of the Biophysical Laboratory of the Bureau of Plant Industry, except as noted.]

Year.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Seasonal.	Total.
1908	[a]0.20	[a]0.19	[a]1.65	1.16	3.95	1.47	1.26	0.62	0.52	[a]2.10	[a]0.20	[a]0.91	9.49	14.23
1909	[a].17	[a].23	[a].19	.84	3.87	5.59	2.45	.55	1.07	.76	.73	1.28	12.94	17.73
1910	.73	.70	.93	1.57	1.26	1.51	1.42	1.03	2.92	.27	.11	.10	6.69	12.55
1911	.13	.05	.09	.17	.45	.50	.80	1.86	.92	.39	.98	.30	2.01	6.64
1912	.24	.10	.71	2.32	2.26	.29	3.20	2.80	3.49	.51	.04	.13	8.78	16.09
1913	.57	.24	.99	.25	1.98	3.10	.35	.26	2.38	1.86	.10	.45	6.67	12.53
Average	.37	.26	.76	1.05	2.29	2.08	1.58	1.19	1.88	.97	.36	.53	7.76	13.41
Maximum	.73	.70	1.65	2.32	3.95	5.59	3.20	2.80	3.49	2.10	.98	1.28	12.94	17.73
Minimum	.13	.05	.09	.17	.45	.29	.35	.26	.52	.27	.04	.10	2.01	6.64

[a] From records of the United States Weather Bureau at Vale and at Orman, S. Dak.

The average precipitation at the Belle Fourche Experiment Farm during the 6-year period under discussion (1908–1913), as shown in Table II, was 13.41 inches. Of this total, 7.76 inches fell during the months from March to July, inclusive, or during the period when small grains make most of their growth. The annual precipitation varied from 6.64 inches in 1911 to 17.73 inches in 1909. The seasonal

precipitation (March to July, inclusive) for the same years varied from 2.01 to 12.94 inches.

The average precipitation at the Belle Fourche Experiment Farm is very near the normal for the western part of the State. The period during which experiments have been conducted includes three years in which the precipitation was less than the normal, one of them being the driest known in the history of the State, and three years in which the precipitation was above normal.

In order to make practical use of field experiments, it is necessary to know to what extent the conditions under which they were conducted are likely to continue through a considerable period of time. For this reason Table III, which gives the annual precipitation at Fort Meade, S. Dak., for a period of 35 years (1879–1913) is included.

The record of precipitation at Fort Meade is practically continuous since 1879. Where there have been omissions, it has been completed from the records at near-by points.

TABLE III.—*Monthly, seasonal, and annual precipitation at Fort Meade, S. Dak., for 35 years, 1879 to 1913, inclusive.*

[Data (in inches) from the records of the Weather Bureau.]

Year.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Seasonal.	Total.
1879	.....	.....	.....	.....	.....	.....	0.78	1.40	0.14	1.60	0.04	0.89	.....	.....
1880	0.38	1.00	0.92	0.75	.....	4.68	1.62	3.91	T[a]	.54	.44	.39	.....	.....
1881	.56	1.30	.95	1.10	3.33	2.66	1.50	1.57	1.00	.63	.46	T[a]	9.54	15.06
1882	.10	.10	.60	4.77	3.87	5.47	3.05	.44	.26	.49	.05	.12	17.76	19.32
1883	2.90	.30	2.16	4.50	9.61	1.56	2.80	.18	1.60	.67	.05	.72	20.63	27.05
1884	.37	.33	2.26	5.04	8.58	.48	1.20	2.30	.23	.75	.53	.90	17.56	22.97
1885	.32	.23	.52	1.30	.64	3.38	1.52	3.22	.28	.74	.93	.17	7.36	13.25
1886	.32	.67	.88	2.17	.57	.90	3.38	1.50	.40	.40	1.60	.72	7.90	13.51
1887	.56	.20	.76	2.12	2.72	1.76	4.46	4.25	1.10	.40	.24	.36	11.82	18.93
1888	1.65	1.29	.75	.20	3.94	5.50	2.64	3.54	.02	.14	.16	.17	13.03	20.00
1889	.27	.85	.12	2.64	2.02	1.60	6.38	0	.67	1.71	.88	.86	12.76	18.00
1890	.55	.46	1.24	1.65	2.31	6.30	.16	1.64	.76	.38	.40	.38	11.66	16.23
1891	.78	.83	1.63	2.29	6.60	4.29	1.75	1.50	.87	.41	.52	.32	16.56	21.79
1892	1.36	.27	.67	5.70	3.30	3.99	1.04	2.93	.32	2.46	1.51	1.54	14.70	24.09
1893	.40	.74	2.41	3.45	2.01	1.63	1.14	.70	0	3.48	1.48	1.68	10.64	19.12
1894	.55	.12	3.08	3.48	1.15	3.80	.57	.42	.62	1.24	1.03	.72	12.08	16.78
1895	.85	[b]1.05	[b]2.26	2.91	3.35	5.05	.55	.95	.80	.23	2.36	.40	14.12	20.76
1896	.66	1.14	3.43	2.51	2.69	2.62	.72	.05	2.46	T[a]	1.27	.06	11.97	17.61
1897	1.33	.05	1.36	1.80	1.07	5.32	2.05	3.11	.01	.02	.50	T[a]	11.60	16.62
1898	1.20	.15	.83	1.20	9.60	2.70	1.20	1.50	1.80	1.54	.33	1.10	15.53	23.15
1899	.91	.46	1.42	4.15	6.75	2.35	.29	.30	1.10	1.94	.14	.56	14 96	20.37
1900	.50	.34	1.14	.95	.35	3.00	2.05	1.90	2.03	.46	.50	.70	7.49	13.92
1901	.47	.99	1.71	1.68	2.83	6.78	2.83	2.75	1.35	.83	.17	.89	15.83	23.28
1902	1.53	2.30	5.53	3.80	3.35	3.57	1.11	.07	.75	.10	.01	.07	17.36	22.19
1903	.50	.90	1.70	2.55	3.36	2.16	4.25	3.56	2.90	.40	.80	.81	14.02	23.89
1904	.26	1.22	.31	.96	4.52	5.76	.40	2.35	.45	1.86	.16	.72	11.95	18.97
1905	.97	.21	1.14	.49	5.94	4.84	10.33	.62	.12	4.95	.64	.12	22.74	30.37
1906	.30	1.42	2.25	.25	5.37	1.85	1.45	5.55	.12	1.20	.92	1.30	11.17	21.98
1907	.60	.40	.30	.85	10.95	8.10	6.23	.04	1.40	0	0	.33	26.43	29.20
1908	.10	1.00	1.15	2.80	3.98	1.87	.50	[b].80	.58	2.20	.32	1.70	10.30	17.00
1909	.12	.12	.42	2.23	10.20	8.53	3.19	.30	1.50	.50	1.70	1.31	24.57	30.12
1910	.57	.10	1.55	2.00	2.70	1.70	1.62	1.44	3.49	.52	1.06	.13	9.57	16.88
1911	.17	.45	[c].09	[c].47	[c].04	[c].62	[c].58	[c]2.29	[c].97	[c]1.06	[c]1.08	[c].58	1.80	8.40
1912	[c].09	.31	1.19	2.90	1.91	.70	2.78	9.15	2.50	.80	T	1.02	9.48	23.35
1913	.95	.60	3.30	.40	3.10	2.08	.25	.93	.68	[c]2.37	[c].14	.30	9.13	15.10
Mean	.68	.64	1.47	2.24	4.02	3.57	2.18	1.92	.94	1.06	.61	.63	13.45	19.86

[a] T = trace.
[b] Record missing; estimated from the records at near-by stations.
[c] Record missing; rainfall at Vale, S. Dak., about 15 miles north of Fort Meade, substituted.

Fort Meade is only about 25 miles south of Newell, but the elevation is 675 feet greater. Its proximity to the Black Hills apparently influences the rainfall to a considerable extent, as the annual precipitation is greater at Fort Meade than at Newell in those years for which the rainfall records of both are available. A comparison of Tables II and III, however, will indicate to some extent the frequency with which conditions of precipitation similar to those prevailing from 1908 to 1913 are to be expected.

The mean annual rainfall at Fort Meade, as shown by Table III, is 19.86 inches for the 33 years from 1881 to 1913. The maximum rainfall for the period, 30.37 inches, was recorded in 1905. The minimum rainfall, 8.40 inches, was recorded in 1911. For practically all of this year, however, there are no records at Fort Meade, so that the rainfall at Vale, S. Dak., has been substituted. The rainfall at Vale is usually considerably lower than at Fort Meade, though the two points are only about 16 miles apart. The lowest annual rainfall actually recorded at Fort Meade is 13.25 inches, the record for 1885.

The rainfall during the growing period for cereals (March to July) also shows a wide variation. The average seasonal rainfall for the 33-year period is 13.45 inches. The maximum rainfall for the five months, 26.43 inches, was recorded in 1907; the minimum (except that of 1911 at Vale), 7.36 inches, was recorded in 1885. In the six years covered by the experiments at Newell the rainfall at Fort Meade during the growing season has exceeded the normal only in 1909.

EVAPORATION.

The seasonal evaporation probably ranks next in importance to seasonal precipitation among the factors which influence the growth of crops at Newell. The daily evaporation has been recorded at the Belle Fourche Experiment Farm, and the total amount in inches by months from April to July is shown in Table IV. The record of evaporation was not kept for the month of March, but at Newell crops ordinarily make little growth during that month and hence this omission is not of importance. The evaporation is determined from a free water surface, the method being that employed at all of the stations where the Biophysical Laboratory of the Bureau of Plant Industry has been cooperating.[1]

The average evaporation for the four months from April to July, inclusive, for the six years from 1908 to 1913 was 27.620 inches. The lowest total evaporation, 23.627 inches, was recorded in 1909, the year of the greatest rainfall during the same months. The highest total evaporation, 33.906 inches, was recorded in 1911, the year of the lowest seasonal rainfall. Thus, the evaporation usually varies inversely with the precipitation, though this is not always the case.

[1] Briggs, L. J., and Belz, J. O. Dry farming in relation to rainfall and evaporation. U. S. Dept. Agr., Bur. Plant Indus. Bul. 188, p. 16–20. 1910.

TABLE IV.—*Monthly precipitation and evaporation from a free water surface at the Belle Fourche Experiment Farm, by months, from April to July of each year, 1908 to 1913, inclusive.*

[Data (in inches) from the records of the Biophysical Laboratory of the Bureau of Plant Industry.]

Year.	April.		May.		June.		July.		Total.		Ratio.
	Precipitation.	Evaporation.	Precipitation.	Evaporation.	Precipitation.	Evaporation.	Precipitation.	Evaporation.	Precipitation.	Evaporation.	
1908	1.16	5.535	3.95	5.917	1.47	6.821	1.26	8.081	7.84	26.354	1: 3.36
1909	.84	3.657	3.87	6.413	5.59	5.859	2.45	7.698	12.75	23.627	1: 1.85
1910	1.57	5.408	1.26	5.306	1.51	8.975	1.42	10.429	5.76	30.118	1: 5.23
1911	.17	4.649	.45	8.302	.50	10.241	.80	10.714	1.92	33.906	1: 17.66
1912	2.32	4.849	2.26	6.423	.29	8.175	3.20	7.980	8.07	27.427	1: 3.40
1913	.25	4.705	1.98	4.302	3.10	7.046	.35	8.235	5.68	24.288	1: 4.26
Average.	1.05	4.801	2.29	6.110	2.08	7.853	1.58	8.856	7.00	27.620	1:3.95

The ratio of precipitation to evaporation, also given in Table IV, shows the evaporation for the six years to be 3.95 times the precipitation. In 1909 the ratio was the narrowest, the evaporation for that year being only 1.85 times the precipitation. In 1911 the ratio was the widest, the evaporation being 17.66 times the precipitation. The ratios of precipitation to evaporation for the different years compared with the average ratio for the entire period afford an excellent basis for judging the seasonal conditions under which the experiments reported in this bulletin were conducted.

WIND.

The record of wind measurements has been taken at the Belle Fourche Experiment Farm during the growing season since May, 1909. The anemometer stands near the evaporation tank, at a height of about 2 feet from the surface of the ground. The average wind velocities in miles per hour during the months from April to July for the years 1908 to 1913, inclusive, are presented in Table V.

TABLE V.—*Average wind velocity at the Belle Fourche Experiment Farm, by months, from April to July of each year, 1908 to 1913, inclusive.*

[Data (in miles per hour) from the records of the Biophysical Laboratory of the Bureau of Plant Industry.]

Month.	1908	1909	1910	1911	1912	1913	Average.
April	.....	9.1	9.2	9.2	9.5	6.2	8.6
May	8.3	10.1	8.2	11.6	11.1	5.9	9.2
June	7.2	6.2	9.3	9.1	7.6	6.8	7.7
July	5.0	6.0	7.7	7.9	6.0	5.8	6.5
Average	6.8	7.8	8.6	9.5	8.6	6.2	8.0

Table V shows the average wind velocity at Newell to be 8 miles per hour from April 1 to July 31. The greatest average wind velocity, 9.2 miles per hour, is for the month of May. In June and July there is a considerable decrease in the velocity of the wind, the average for

the latter month being 6.5 miles. The greatest seasonal velocity was recorded in 1911, which was the year of least rainfall and greatest evaporation. The highest average velocity for the entire period was recorded in May of that year, 11.6 miles per hour. The average velocity for both June and July was also unusually high. The low yields in 1911 were due to the combination of very low rainfall, high evaporation, and injury to crops from high winds. The wind for any one day (24 hours) seldom exceeds a total of 500 miles, while for any one day during June and July it is usually much less than 250 miles.

TEMPERATURE.

The temperatures at the Belle Fourche Experiment Farm are recorded throughout the year by means of maximum, minimum, and dry-bulb thermometers. A summary of the mean, maximum, and minimum temperatures from April to July, inclusive, for the six years from 1908 to 1913 is presented in Table VI.

TABLE VI.—*Mean, maximum, and minimum temperatures at the Belle Fourche Experiment Farm, by months, from April to July of each year, 1908 to 1913, inclusive.*

[Data (in °F.) from the records of the Biophysical Laboratory of the Bureau of Plant Industry.]

Year.	April.			May.			June.			July.			Seasonal mean.
	Mean.	Maximum.	Minimum.	Mean.	Maximum.	Minimum.	Mean.	Maximum.	Minimum.	Mean.	Maximum.	Minimum.	
1908	48	89	5	52	79	29	63	90	39	73	100	43	59
1909	38	73	6	52	84	22	66	95	45	70	100	41	56
1910	51	89	24	52	81	27	68	108	36	76	109	44	62
1911	43	88	13	58	94	23	73	101	43	71	105	41	61
1912	47	78	22	55	84	32	66	101	39	70	94	40	60
1913	48	89	24	53	95	26	66	98	45	70	101	42	59
Average	46	84	16	54	86	26	67	99	41	72	101	42	59.5

Table VI shows that the highest average mean, maximum, and minimum temperatures have been recorded in July, though the maximum and minimum temperatures are only very slightly higher than those recorded in June. During the six years, frost has not occurred in June, the lowest minimum temperature recorded being 36° F. This table shows that the average mean temperature for the growing season for cereals for the six years is 59.5° F. The greatest variation from this average in any one year was in 1909, when the seasonal mean was 56° F.

The temperature of western South Dakota is somewhat higher than that of corresponding latitudes in the eastern part of the State. This is shown in Table VII, in which the mean monthly and annual temperatures at Newell, Camp Crook, Aberdeen, Pierre, and Brookings are given. Camp Crook is near the northwestern corner of the State,

about 60 miles north and 30 miles west of Newell. Aberdeen is directly east of Camp Crook, but is about 90 miles from the eastern boundary. Pierre is on the Missouri River in the central portion of the State. Brookings is in the same latitude as Pierre, but within 20 miles of the eastern boundary.

TABLE VII.—*Mean monthly and annual temperatures at Newell, Camp Crook, Aberdeen, Pierre, and Brookings, S. Dak., for the periods indicated.*

[Data (in °F.) for Newell from the records of the Biophysical Laboratory of the Bureau of Plant Industry and for other stations from the records of the United States Weather Bureau.]

Months.	Newell.	Camp Crook.	Aberdeen.	Pierre.	Brookings.
	6 years (1908–1913).	20 years (1894–1913).	23 years (1891–1913).	21 years (1893–1913).	24 years (1890–1913).
January	[a] 15.0	17.7	9.6	14.1	12.2
February	[a] 19.0	18.9	11.2	16.9	13.8
March	[a] 31.8	28.2	26.2	29.4	28.5
April	45.8	43.9	44.8	46.7	45.0
May	53.7	54.1	55.9	59.1	55.2
June	67.0	63.2	66.1	69.1	65.1
July	71.7	69.5	70.9	75.2	69.6
August	69.7	68.7	68.7	73.3	67.9
September	59.0	58.6	59.0	62.9	59.7
October	45.3	45.6	45.7	48.9	46.3
November	33.2	31.3	28.8	32.0	29.5
December	21.3	23.7	16.9	20.5	19.6
Annual	44.4	43.6	42.0	45.7	42.7

[a] For five years only.

The record of mean temperatures at Newell is for a much shorter period than the records for the other localities noted in Table VII, so that the figures are not entirely comparable. The annual mean and monthly mean temperatures at Newell differ only slightly from those at Camp Crook.

The annual mean temperatures in western South Dakota are shown to be slightly higher than those in the eastern part of the State. The difference between the mean temperature at Camp Crook and at Aberdeen is 1.6 degrees, while that of Pierre is 3 degrees higher than that of Brookings. The variation between the Brookings and Pierre temperatures is quite constant throughout the year, but most of the variation between the Camp Crook and Aberdeen temperatures occurs in December, January, and February. The average of the mean temperatures for these three months is 7.9 degrees lower at Aberdeen. This variation in winter temperatures perhaps accounts for the fact that winter wheat is more likely to winterkill in eastern than in western South Dakota.

Table VIII gives the dates of the last spring and first fall frosts and the number of days in the frost-free period during each year from 1908 to 1913, inclusive. The latest date on which frost has occurred in the spring during the six years was May 23, and the average date

was May 13. The earliest frost in the autumn during this period was on August 27, while the average date of the first frost was September 14. The average frost-free period for the six years is 123 days.

TABLE VIII.—*Dates of killing frosts, the last in spring and the first in autumn, with temperatures recorded and length of the frost-free period for each year from 1908 to 1913, inclusive, at the Belle Fourche Experiment Farm.*

[Data from the records of the Biophysical Laboratory of the Bureau of Plant Industry.]

Year.	Last frost in spring.		First frost in fall.		Frost-free period.	Year.	Last frost in spring.		First frost in fall.		Frost-free period.
	Date.	Temperature.	Date.	Temperature.			Date.	Temperature.	Date.	Temperature.	
		°F.		°F.	Days.			°F.		°F.	Days.
1908	May 20	29	Sept. 26	22	129	1912	May 4	32	Sept. 23	32	141
1909	May 17	26	Sept. 23	31	128	1913	May 6	32	Sept. 24	29	140
1910	May 23	31	Aug. 25	32	93						
1911	May 11	30	Aug. 27	32	107	Average	May 13	.....	Sept. 14	.....	123

EXPERIMENTAL METHODS.

The tests with dry-land cereals on the Belle Fourche Experiment Farm have been conducted in field plats and in the nursery. In the field plats varietal tests and tests of rates and dates of seeding have been included. The plats have ranged from one-fiftieth to one-tenth of an acre in size. In the cereal nursery the varieties have been grown in short rows. The use of the nursery has made it possible to test economically a much larger number of varieties than could have been grown in the field plats. Careful records have been kept of the behavior of the varieties included in both the plat and nursery experiments.

PLAT EXPERIMENTS.

The field tests have included varietal tests of winter wheat, rye, and emmer and of spring wheat, oats, barley, and flax. There have also been rate-of-seeding tests with spring wheat and oats and date-of-seeding tests with flax and winter wheat.

SIZE OF PLATS.

All of the plat experiments in 1908 and 1909 and nearly all in 1910 were conducted on tenth-acre plats. These plats were 2 rods wide by 8 rods long. They were arranged side by side in series, the plats in the series being separated by 5-foot alleys. The series were separated by 16.5-foot or 20-foot roads. Each plat thus had a 5-foot alley along each side and a 16.5-foot or 20-foot road along each end.

Most of the tests in 1911 and all of those in 1912 and 1913 were in plats made by sowing a single drill width across an 8-rod series. As the drill was 6 feet wide, this gave a plat of one-fifty-fifth of an

acre in area. The alleys between these plats have been 19.2 inches in width. By the use of plats and alleys of these dimensions it was possible to sow five plats within the area formerly occupied by one tenth-acre plat. As the plants draw considerable moisture and plant food from the alleys, it has been thought fair to consider these one-fifty-fifth-acre plats as one-fiftieth-acre plats in computing acre yields.

REPLICATION OF PLATS.

In 1908, 1909, and 1910, when the tests were conducted on tenth-acre plats, there was only a single plat of each variety. Check plats of standard varieties of each cereal were sown at regular intervals in 1909 and 1910, and in most of the tests in 1908. As this method did not appear to be entirely satisfactory, a change was made in 1911 in some of the tests and in all those conducted in 1912 and 1913. The size of the plats was reduced, as stated in the preceding paragraph, and the tests were replicated. In the varietal tests, five plats of each variety were grown. In rate-of-seeding and date-of-seeding experiments it has been considered sufficient to grow three plats of each rate or date, as there is a correlation between the different parts of the experiment which is not found in the varietal tests.

PREPARATION OF THE LAND.

In preparing the land for experimental work the aim has been to keep within practical farm limits as far as possible. The plowing has been done at a moderate depth, 6 to 8 inches, and subsequent treatment has been in accord with the best farm practice. The necessity for keeping the land uniform has sometimes required hand work, such as the removal of weeds, and probably more cultivation at times than would be done by a practical farmer. The work also has been more timely than is usually the case on large farms.

Most of the experimental work has been on land fallowed during the preceding year. Fallowing also has been necessary to insure uniformity in soil conditions. When the experimental work was begun, this appeared to be the most practicable method of producing crops under dry-land conditions.

The usual practice has been to plow in the fall after the crop was removed, or the following spring if conditions were not favorable for fall plowing. Ground plowed in the fall has been left rough or has been worked down with the disk and spike-tooth harrows, according to the moisture condition. If it contained considerable moisture it was worked; otherwise it was not. All fallow has been worked when necessary to remove weeds or to prevent evaporation. The spring-tooth harrow has proved to be the most satisfactory tool for working fallow land. Other implements, such as the smoothing

harrow and disk harrow, pulverize the soil to a greater extent and increase the danger from soil blowing.

The only varietal tests here reported which were not conducted on fallowed land are those with oats, barley, and flax in 1913. The varietal test of oats was on corn ground, which was disked and harrowed into good condition before seeding. The barley varieties were grown on land cropped to wheat the previous season, which was plowed about 10 inches deep soon after the wheat was taken off and was worked down with disk and harrow immediately after plowing. The flax varieties were sown on land on which small grain was grown in 1912, the preparation being the same as that for barley.

The rate-of-seeding test with spring wheat in 1910 and with oats in 1913 and the date-of-seeding test with flax in 1913 were on land on which corn was grown the previous year. The land was disked and harrowed but was not plowed before seeding. The rate-of-seeding test with spring wheat in 1913 was on land cropped to small grain the preceding season and prepared the same as that for the barley varieties.

RATES AND DATES OF SEEDING.

The usual rate of seeding for spring wheat has been from 4 to 5 pecks to the acre; for winter wheat, 3 pecks; for oats, 6 pecks; for barley, 5 pecks; and for flax, 2 pecks.

Spring grains have been sown as early as seemed practicable, seldom before April 1 or later than April 15. Winter grains have been sown at what was thought to be the most favorable date each year. This has usually been between September 15 and October 1.

NURSERY EXPERIMENTS.

The nursery tests at Newell have included varieties newly introduced and those of which there was not sufficient seed for sowing in the field plats, and also pure-line selections from the better commercial varieties. The latter has been the most important feature of the nursery work. The varieties and selections have been grown in short rows, thus making possible the economical testing of a very much larger number of varieties and races than could have been included in the plat tests.

NATURE OF THE WORK.

Although the improvement of the cereal crops by selection has required a considerable outlay of time and money, the results are less than were expected at the outset. This is due to several causes, the most important of which are the partial or complete crop failures resulting from the extremely dry seasons. This has prevented sufficient increase of the more desirable strains for a thorough test in

field plats. In many cases the drought has been so severe that all the races and varieties failed to mature grain, regardless of their ability to evade or resist moderate droughts.

When work was begun at the Belle Fourche Experiment Farm, the best crops and varieties for that section were fairly well known. It seemed, therefore, that the best plan in crop improvement was to select from these few varieties rather than from many which might prove to be unadapted. As the better varieties were for the most part unselected, this line of work seemed to be specially promising.

It appeared that isolation of these types and a study of their characteristics and values ought to precede attempts to improve them by hybridization. Accordingly, in 1908, several hundred selections were made from winter wheat, spring durum wheat, spring common wheat, and oats. These were mainly from Turkey, Kharkof, and Crimean winter wheat, Kubanka durum wheat, and Sixty-Day and Kherson oats. Additional selections from these and other varieties were made in subsequent years.

NURSERY METHODS.

Single heads were selected from the field plats, the aim being to obtain as many types as possible. Each head was described carefully before it was thrashed. The seeds from each head were then sown in a 5-foot row. The number of kernels sown in each row was usually 25. The dates of planting, emergence, heading, and ripening were recorded, as were such other notes on hardiness, yield, etc., as appeared to be desirable. At harvest the rows which seemed to be especially undesirable were discarded, but in all cases at least one selection of each type was retained for further study. Most of these races which were retained were sown with an ordinary grain drill in 60-foot rows in 1910 and succeeding seasons. As far as possible, replicate plantings have been made, but loss of seed in unfavorable seasons and lack of land and labor have made impossible as frequent replication as has seemed desirable.

INTERPRETATION OF EXPERIMENTAL RESULTS.

The best variety or method of culture is the one which, on the average, will produce the highest yield of grain of the greatest value at the least cost. It is seldom that a single variety or method will fulfill all these requirements for all seasons. Usually one will give the best results one season, another the second, and perhaps still another the third. The best method or variety, presumably, is that one which gives the best average during a series of years, provided the seasons are representative. In actual practice, however, the problem is more complicated than would appear from this statement. The variation

in soil and in seasons, the importance of weather and soil conditions at critical stages of growth, and the variable reaction of varieties to seasonal conditions make it difficult to arrive at definite conclusions by a study of averages alone.

EXPERIMENTS WITH WHEAT.

The experiments with wheat at Newell have included plat and nursery tests of both spring and winter varieties. In addition to the varietal tests there have been rate-of-seeding experiments with spring wheat and date-of-seeding experiments with winter wheat.

Because there is always a ready market for the grain and its value is high in comparison with its bulk, wheat is always an important crop in a newly settled district. For that reason the experiments with wheat at Newell have been more extensive and of greater popular interest than those with any other grain. Considerable effort has been devoted to the improvement of varieties by selection.

SPRING WHEAT.

Spring wheat is much more commonly grown in western South Dakota than winter wheat. There is considerable diversity in varieties, for both common and durum wheats are grown. The common wheats include representatives of the Fife, bluestem, and Preston (bearded Fife) groups. A varietal test of spring wheat has been conducted on the Belle Fourche Experiment Farm each year since 1908. A rate-of-seeding test with Kubanka durum wheat was begun in 1909 and was continued throughout the period here discussed.

VARIETAL TEST OF SPRING WHEAT.

The spring-wheat varieties included in the tests at Newell are those which have given the best results in other dry-land districts, with the addition of a few which have been introduced recently from foreign countries. Because so many of the poorer ones were eliminated by previous tests elsewhere, the varieties grown at Newell do not show wide variations in yield.

Twelve varieties and strains of durum wheat and thirteen of common wheat have been grown in plats. In some cases several lots of the same variety from different sources have been included in the test. Therefore, only 6 varietal names of durum and 10 of common wheat are represented by the 25 lots. The annual and average yields for all varieties and strains are shown in Table IX.

As shown in Table IX, good yields of spring wheat were produced in 1908, 1909, and 1913, fair yields of some varieties in 1910, and failures of practically all varieties in 1911 and 1912. Only five of the durum varieties and strains and five of the common varieties have been grown during all of the six years (1908–1913).

TABLE IX.—*Annual and average yields of varieties of spring wheat on the Belle Fourche Experiment Farm, 1908 to 1913, inclusive.*

Group and variety.	C. I. No.[a]	Yield per acre (bushels).						
		1908	1909	1910	1911	1912	1913	6-year average.
Durum:								
Adjini	2941	18.3						
Arnautka	1493	22.3	22.6	8.3	0	0	17.1	11.7
Do	1537			11.5	0	0		
Do	1547	21.3	22.0	9.2	0	0		
Kubanka	1354	24.8	19.5	4.0	0	0		
Do	1440	24.9	[b]21.4	[c]7.4	0	0	15.6	11.6
Do	1516	[c]23.8	22.6	5.3	0	0	19.1	11.8
Do	2246	21.0						
Do	2882	23.2						
Pelissier	1584	21.7						
Pererodka	1350	22.5	23.2	5.2	0	0	16.7	11.3
Yellow Gharnovka	1444	22.7	20.9	5.0	0	0	16.5	10.9
Fife:								
Ghirka	1517	16.2	11.7	12.8	0	1.9	16.3	9.8
Glyndon (Minn. No. 163)	2873					0	15.8	
Marquis	3276					3.8	16.8	
Power	3025	18.5	17.3	10.6	0	0	16.6	10.5
Rysting	3022	19.3	15.0	10.3	0	0	15.0	9.9
Bluestem:								
Haynes	2874					0	14.2	
Do	3020	18.3	13.8	9.0	0	0	14.1	9.2
Do	3021	17.0						
Preston:								
Preston	3081					0	19.5	
Do	3087					0	19.0	
Spring Turkey	4154					0	16.2	
Miscellaneous:								
Changli	2911					11.7	14.6	
Manchuria	2492	16.2	16.0	12.8	0	4.5	17.1	11.1

[a] Cereal Investigations number. [b] Average of two check plats. [c] Average of three check plats.

The rainfall in 1908 and 1909 was fairly heavy and its distribution was particularly favorable to spring grains, as the greater portion came during the growing season. In 1910 the ground was in excellent condition for seeding and the prospects for a crop were excellent until about June 1. The rainfall was so light during the growing season, however, that many of the varieties did not produce grain. There were only two rains of more than 0.5 inch between April 15 and the time the wheat matured, and these two only slightly exceeded that quantity. As a shower of less than 0.5 inch is soon evaporated and is of little benefit to growing crops, particularly in a dry season, the conditions were especially trying during 1910. The moisture stored in the soil the previous season was the principal factor in crop production.

A surprising feature of the varietal test in 1910 was the larger yields produced by the common spring wheats in a season when it appeared that the durum varieties should have yielded best. The production of straw of the latter was sufficient for a heavy yield of grain, much greater than from the common varieties. From the appearance of the plats they seemed to have withstood the drought better than the common wheats, but when they matured it was found that many heads contained little or no grain. The only explanation of the differ-

ence in yield between the durum and common varieties that appears plausible is that the durum wheats bloomed during a hot, dry period, about June 20, while most of the common varieties bloomed about a week later, when weather conditions were more favorable. Low yields of durum wheat were obtained at several stations in the Great Plains in 1910 and 1911, and in every case it was noted that the durum varieties bloomed during a hot, dry period. This matter has been discussed more at length by the writer in another publication.[1]

The crop season of 1911 was so dry that spring grain sown at the usual time did not germinate till August. Table II shows that the total precipitation from March to July, inclusive, was only 2.01 inches and that, with one exception, this precipitation came in such small showers that it was of no value in promoting crop growth. No yields of any of the cereals were produced that year.

The soil was so dry in the spring of 1912 that only small yields were produced that year, even though the precipitation was nearly normal. The rainfall during May and June was light, and this factor contributed further toward the partial failure of the crops. In that year all the replicated plats of only two varieties of spring wheat, the Ghirka and Manchuria, were harvested. Only single plats of the Changli and Marquis were grown; these produced the yields shown in Table IX. None of the other varieties produced enough grain to harvest. All four of the varieties which matured grain in 1912 are early and so in a measure escaped the effect of the drought.

In 1913 five fiftieth-acre plats of each variety were sown, but on a portion of the area the germination and growth were not at all uniform, probably due to the replowing of the land the previous summer to eradicate gumbo weed. Two plats of each variety were sown on land which received uniform treatment, so the results from these plats only are included in Table IX.

Two plats of the Galgalos wheat, C. I. No. 2398, a beardless variety with short, stiff straw and a rather large, soft, white kernel, were grown on land not entirely comparable with that on which the varieties shown in Table IX were sown. Plats of the Kubanka and Power were grown, however, on the same area. The Galgalos produced an average yield of 17.5 bushels, the Kubanka 18.1 bushels, and the Power 14.3 bushels.

SUMMARY OF YIELDS OF SPRING WHEAT.

Of the numerous varieties of spring wheat grown at Newell, only 10 have been included in the test for the entire period of six years. Of these 10 varieties, 5 are durum and 5 are common wheats. Of the common wheats, 3 belong to the Fife group, 1 to the bluestem, and 1,

[1] Salmon, Cecil. Sterile florets in wheat and other cereals. *In* Jour. Amer. Soc. Agron., v. 6, no. 1, p. 24–30, 2 pl., 1914.

the Manchuria, is a bearded wheat which does not belong to any group now commonly grown in this country.

Table X shows the average date of heading and of maturity, height, and weight per bushel of these 10 varieties in 1908, 1909, 1910, and 1913. In 1911 none of the varieties matured grain, so that none of these data are available for that year, while in 1912 data were obtained for only two or three varieties.

Table X also shows the average yields per acre of grain and of straw for these varieties. The yield of grain is the average for the entire period of six years, 1908 to 1913. These yields are shown graphically in figure 2. The yield of straw is for five years, 1912 being excluded for the reason that only two of the varieties were harvested, though all of them made some growth. The groups and varieties are arranged in the table according to their average yield of grain per acre.

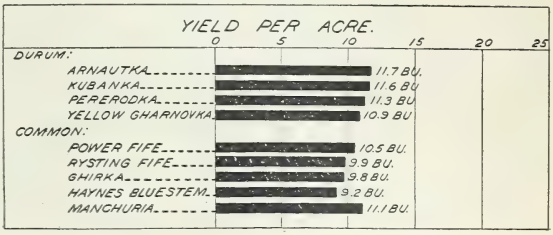

FIG. 2.—Diagram showing the average yields per acre, in bushels, of the leading varieties of spring wheat at the Belle Fourche Experiment Farm, for six years, 1908 to 1913, inclusive.

TABLE X.—*Average dates of heading and of maturity, height, weight per bushel, and yields of the 10 leading varieties of spring wheat on the Belle Fourche Experiment Farm, 1908 to 1913, inclusive.*

[The groups and varieties are arranged according to their average yield per acre.]

Group and variety.	C. I. No.	Date of—		Height.[a]	Weight per bushel.[a]	Yield per acre.	
		Heading.[a]	Maturity.[a]			Grain.[b]	Straw.[c]
Durum:				*Inches.*	*Pounds.*	*Bushels.*	*Pounds.*
Kubanka	1516	July 1	July 27	30	62.2	11.8	1,540
Arnautka	1493	June 30	...do...	33	62.4	11.7	1,570
Kubanka	1440	July 2	July 28	32	61.8	11.6	1,590
Pererodka	1350	...do...	July 30	33	62.5	11.3	1,700
Yellow Gharnovka	1444	...do...	July 28	34	62.4	10.9	1,730
Miscellaneous:							
Manchuria	2492	June 29	July 25	30	58.9	11.1	1,390
Fife:							
Power	3025	July 6	July 28	28	59.7	10.5	1,370
Rysting	3022	July 7	July 29	28	55.9	9.9	1,370
Ghirka	1517	June 27[d]	July 20[d]	[d]27	57.6	9.8	1,200
Bluestem:							
Haynes	3020	July 9	July 30	28	55.4	9.2	1,320

[a] Average for four years (1908–1910 and 1913), except as noted.
[b] Average for six years, 1908 to 1913, inclusive.
[c] Average for five years (1908–1911 and 1913).
[d] Average for two years, 1912 and 1913.

LEADING VARIETIES OF SPRING WHEAT.

As shown in Table X, the best yields of spring wheat at Newell have been obtained from the durum varieties, Kubanka and Arnautka. Some of the varieties of common wheat, however, have produced

yields nearly as high as those of the best durum varieties. Brief descriptions of the more important varieties of durum and common wheat grown at Newell are given herewith, and heads of typical varieties are shown in figure 3. A more complete discussion of hard spring-wheat varieties will be found in another publication.[1]

Durum wheat.—The heads of durum wheat[2] are broader and more compact and the beards are longer than those of the spring common varieties. The kernels are large and very hard and are usually clear amber in color. There is considerable variation among the durum wheats in the color of chaff and of beards. The leading varieties at Newell all have yellowish, hairless chaff and yellow beards. They all belong to the Kubanka group of durum wheats.

The highest average yields for the six years from 1908 to 1913, inclusive, were produced by the Kubanka, C. I. Nos. 1440 and 1516, and

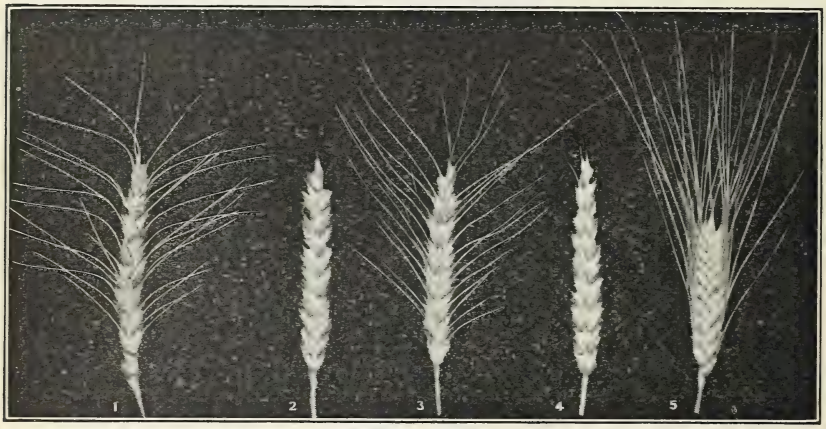

FIG. 3.—Representative heads of the different groups of wheat discussed in this bulletin: *1*, Turkey winter; *2*, Fife; *3*, Preston; *4*, bluestem; *5*, durum.

the Arnautka, C. I No. 1493. There is practically no difference in the average yields of these three lots, nor is there much difference in the appearance of the varieties. Somewhat lower yields were produced by the Pererodka and Yellow Gharnovka varieties, though the difference even here is slight.

All these varieties except the Arnautka were introduced into the United States from Russia by the United States Department of Agriculture in 1899 and have since been grown in the northern Great Plains. The Arnautka variety was brought in and grown by farmers at an earlier date. It is still probably more widely grown than any other durum wheat in the United States, though the quality of the

[1] Ball, C. R., and Clark, J. A. Varieties of hard spring wheat. U. S. Dept. Agr., Farmers' Bul. 680, 20 p., 7 fig., 1915.

[2] For a more complete discussion of durum wheat, see Salmon, Cecil, and Clark, J. A. Durum wheat. U. S. Dept. Agr., Farmers' Bul. 534, 16 p., 4 fig., 1913.

Kubanka is higher. The best durum wheat to grow in western South Dakota is the Kubanka. A field of this variety on the Belle Fourche Experiment Farm is shown in figure 4.

Common wheat.—All the spring common wheats which have been grown at Newell for more than one year have hard or semihard red kernels. They vary chiefly in the hairiness of the chaff, in the presence or absence of beards, and in the quality of the grain.

The highest yield of the spring common wheats has been produced by a variety called Manchuria, C. I. No. 2492. The average yield of this variety for six years is 11.1 bushels, slightly less than that of the best durum wheats. The Manchuria is an early, bearded variety, with hairless, brown chaff, and medium-sized, semihard, red kernels. It has produced fairly good yields at Newell because of its earliness. Its milling qualities are poor and it is not to be recommended.

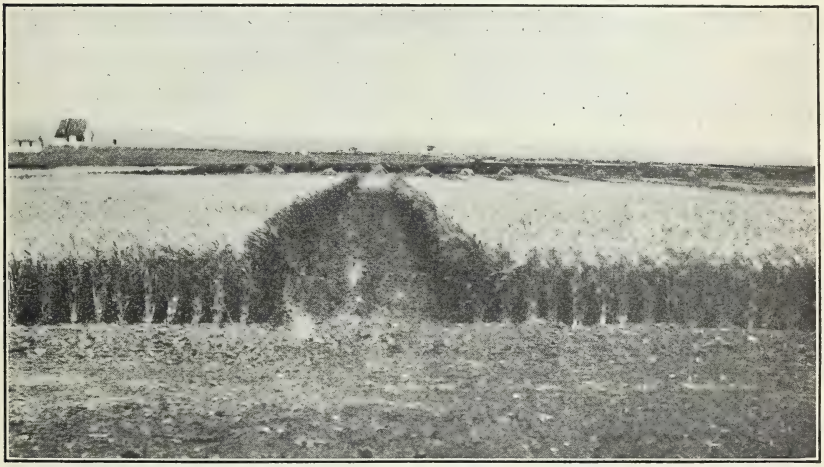

FIG. 4.—Plats of Kubanka durum wheat on the Belle Fourche Experiment Farm in 1910.

Three varieties of Fife wheat have given slightly lower yields than the best durum wheats. These three Fife wheats are the Power, Rysting, and Ghirka. The Power and Rysting are somewhat later in heading than the durum varieties, but mature at about the same time. The Ghirka is slightly earlier than any of the durums.

The Fife is one of the standard groups of hard red spring wheat in Minnesota and the Dakotas. The Fife wheats all have slender, rather open, beardless heads, with white, hairless chaff.

If common spring wheat is to be grown in western South Dakota, some variety of the Fife group should be chosen. In addition to the three here mentioned, the Marquis, a variety which originated in Canada and which has given excellent results in the Canadian Prairie Provinces, is worthy of trial. It is very early in maturing and is of

excellent milling quality. The Marquis was one of the few varieties which matured grain in 1912, while in 1913 it produced a slightly higher yield than any other variety of Fife wheat grown at Newell.

The bluestem wheats, another of the important groups of hard red spring wheats, have given rather poor yields at Newell. The only variety which has been grown for the entire six years is the Haynes, C. I. No. 3020. This variety is also known as Minnesota No. 169. The bluestem wheats have beardless heads, with hairy, white chaff. They mature slightly later than the Fife varieties, and for that reason probably have not given as good yields as the latter.

The only other group of common spring wheat of importance in western South Dakota is the Preston (bearded Fife). The varieties of this group have been grown only two years—1912 and 1913. In 1912, in common with practically all other wheat varieties, they produced no grain. In 1913 they produced higher yields than any of the other common wheats. The Preston, C. I. No. 3081, produced the highest yield of any variety under trial that year, including the durums. One or two varieties of the Preston group appear to be worthy of further trial.

RATE-OF-SEEDING TEST OF SPRING WHEAT.

A rate-of-seeding test with Kubanka durum wheat was conducted in 1909, 1910, 1912, and 1913. The seed, the preparation of the ground, and the date of seeding have been identical for all plats. In 1909 and 1912 this test was conducted on land which was fallow the previous year. In 1910 it followed corn and in 1913 was on land which produced a very small crop of wheat the preceding season.

In 1909 and 1910 single tenth-acre plats and in 1912 and 1913 three fiftieth-acre plats were sown at each rate. The rates varied from 2 to 8 pecks per acre, but only the 4, 5, 6, and 8 peck rates were sown in each of the four years. Table XI shows the annual and the average yields of grain and of straw from the different rates of seeding.

TABLE XI.—*Annual and average yields of Kubanka durum wheat in a rate-of-seeding test on the Belle Fourche Experiment Farm in 1909, 1910, 1912, and 1913.*

Rate of seeding.	Yield per acre.									
	1909		1910		1912		1913		Average.	
	Grain.	Straw.	Grain.	Straw.	Grain.	Straw.	Grain.	Straw.	Grain.	Straw.
	Bush.	*Lbs.*	*Bush.*	*Lbs.*	*Bush.*	*Lbs.*	*Bush.*	*Lbs.*	*Bush.*	*Lbs.*
2 pecks	12.5	870	5.5	1,470	.....	.....	.....	.....	.....	.....
3 pecks	.....	.....	.....	.....	0	0	9.3	1,810	.....	.....
4 pecks	14.4	1,055	5.5	1,270	0	0	9.8	1,860	7.4	1,046
5 pecks	16.8	1,650	2.8	830	0	0	10.4	1,830	7.5	1,077
6 pecks	17.2	1,230	1.8	690	0	0	9.9	1,800	7.2	930
7 pecks	.....	.....	.....	.....	0	0	10.3	1,740	.....	.....
8 pecks	17.9	1,365	3.4	745	0	0	10.6	1,780	8.0	972

In 1909 and 1913, as shown in Table XI, fairly good yields of both grain and straw were obtained. In 1910 the yields were very small, and in 1912 there was not sufficient growth on any of the plats to make them worth harvesting. In the particularly favorable year 1909, the higher rates of seeding gave the best yields. There was little difference in the yields from the different rates in the somewhat less favorable year 1913. In 1910, a very unfavorable year, the plats from the lower rates produced the best yields and in 1912 they made the best growth early in the season. None of the plats, however, produced grain in the latter year.

The average yields of grain for the four years from the 4, 5, 6, and 8 peck rates show very slight variation. The highest yield, 8 bushels to the acre, was produced from the 8-peck rate, while the lowest yield, 7.2 bushels, was produced from the 6-peck rate. The 4-peck rate produced an average yield of 7.4 bushels, only 0.6 bushel less than was produced from sowing 8 pecks. In other words, the extra bushel of seed required at the 8-peck rate produced a gain of only 0.6 bushel in the resulting crop, so that the higher rate really entailed a slight loss. The yield of straw is considerably higher from the 4 and 5 peck rates than from the 6 and 8 peck rates.

While the data here presented are far from conclusive, they indicate that it is safer to sow 4 or 5 pecks of durum spring wheat in western South Dakota than to sow a larger quantity. Because of the smaller size of the kernels of common wheat and the consequent greater number in a peck, the proper rate of seeding for spring common wheat is 3 or 4 pecks to the acre.

NURSERY EXPERIMENTS WITH SPRING WHEAT.

The nursery experiments with spring wheat on the Belle Fourche Experiment Farm have been confined to the testing of pure-line selections of the more important varieties. In 1908 about 100 heads each of durum wheats and of spring common wheats were selected from the varieties in plat tests. These were grown in head rows the following year. In 1910 these selections were grown in 60-foot rows, and in 1911 in 60-foot rows replicated four or five times. The durum-wheat selections were complete failures in 1911 and produced little grain in 1912, so that only a very small quantity of seed was available for testing in 1913. Only slightly better results were obtained from the selections of common wheat.

None of the selections has as yet shown any marked superiority over the parent varieties, though there has been considerable variation among the different selections from the same variety. These variations consist principally of differences in earliness, height, yield, and quality of grain. In many cases a selection which has appeared to be particularly good one year has given poor results the next, so

that it can not be said that any material advance has been made. More extensive trials, particularly of the earlier varieties, appear to be desirable.

WINTER WHEAT.

VARIETAL TEST.

Winter wheat has been grown successfully at Newell in four of the six years from 1908 to 1913. In 1911 the spring rainfall was so deficient that the winter wheat died before making much growth, although the winter survival of all varieties was good. In the fall of 1911 the soil was so dry that the wheat did not germinate; hence, no crop was produced in 1912.

Winter wheat has been sown each year on land fallowed the previous summer. The date of seeding in each case has been that which seemed to be most favorable in the particular season. The rate of seeding usually has been 4 pecks to the acre.

The annual and average yields of the varieties of winter wheat grown on the Belle Fourche Experiment Farm from 1908 to 1913 are shown in Table XII.

TABLE XII.—*Annual and average yields of varieties of winter wheat on the Belle Fourche Experiment Farm, 1908 to 1913, inclusive.*

C. I. No.	Variety.	Yield per acre (bushels).						
		1908	1909	1910	1911	1912	1913	Average.
2979	Alberta Red			16.7	0	0	35.0	
1667	Beloglina			19.2	0	0	37.2	
2239	Do			19.2	0	0	39.4	
1435	Crimean	18.7	31.5	19.7				
1437	Do	25.3	36.0	20.3	0	0	36.4	19.7
1442	Kharkof	25.4	40.3	22.7	0	0	38.6	21.2
1583	Do	22.5	39.0	23.6	0	0	38.8	20.7
2208	Do			17.5				
1561	Theiss			19.4	0	0	36.8	
1558	Turkey	24.1	41.0	17.8	0	0	38.1	20.2
1571	Do	25.5	39.0	20.3	0	0	38.7	20.6
2943	Do			15.0	0	0	39.3	
2998	Do			14.2				
3055	Do	22.3	44.5	(1)	0	0	35.0	17.0

[1] Did not emerge in the fall.

In the fall of 1907 the winter-wheat varieties were sown on new land which had been broken the previous spring and disked during the summer to keep down weeds. The seven strains grown that year were all of the hard red winter or Turkey group. The varietal names included Turkey, Kharkof, and Crimean. Two sowings were made of each variety, one on September 15 and one on October 5. The plants from both dates of seeding made a small growth before winter. The winterkilling ranged from 25 to 45 per cent in the various plats. The favorable spring conditions caused the plants to tiller, so that at harvest time the stand was about normal. The

average yields from the two dates of seeding varied from 18.7 to 25.5 bushels to the acre.

The same varieties were grown in 1909 as in 1908. The growth in the fall of 1908 was small. There was some damage from the blowing of the soil the following spring, for the most part at one end of all the plats. For this reason only a part of each plat was harvested and the yield determined therefrom. The yields were considerably higher than in 1908, ranging from 31.5 to 44.5 bushels. A view of the winter-wheat plats after harvest in 1909 is shown in figure 5.

In the fall of 1909 the number of varieties was increased to 14 by including 7 which had made a particularly favorable showing in nursery plats the previous season. These latter were grown on fiftieth-acre plats, while the other varieties were grown on tenth-acre plats. The preparation of the soil and the date and rate of seeding

FIG. 5.—Winter-wheat plats on the Belle Fourche Experiment Farm after harvest in 1909.

were the same for all plats, however, so that the yields are comparable. One of the strains of Turkey, C. I. No. 3055, did not germinate, but all the other varieties germinated well and made a little growth before winter. The following spring there was some damage from the blowing of the soil, but the winter survival was fairly good, and quite favorable yields were obtained.

In 1911 and 1912, as previously stated, failures were recorded from all of the varieties of winter wheat. In the fall of 1912 eleven varieties were sown under favorable conditions. Three fiftieth-acre plats of each variety were sown instead of a single tenth-acre plat, as in previous years. The growth during the fall was particularly good, and as the winter was mild there was practically no winterkilling. The rainfall during the growing season was sufficient for crop growth, so that yields ranging from 35 to 39.4 bushels to the acre were

produced. The highest yield was obtained from the Beloglina, C. I. No. 2239.

Of the fourteen varieties and strains of winter wheat grown on the Belle Fourche Experiment Farm only five have been sown in each of the six years. The average date of heading and of maturity, weight per bushel, and yield of grain and of straw of these five varieties are given in Table XIII. The yields of grain are shown graphically in figure 6. Table XIII shows that there is practically no variation in the date of heading and of maturity and in the weight per bushel of these stocks and that the variation in yield of grain and straw is very slight.

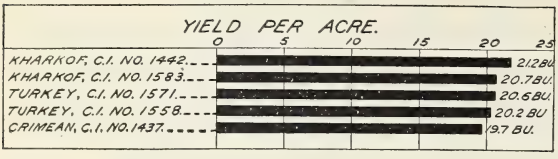

FIG. 6.—Diagram showing the average yields per acre, in bushels, of the leading varieties of winter wheat at the Belle Fourche Experiment Farm, for six years, 1908 to 1913, inclusive.

TABLE XIII.—*Average dates of heading and of maturity, weight per bushel, and yields of five varieties of winter wheat grown continuously on the Belle Fourche Experiment Farm, 1908 to 1913, inclusive.*

C. I. No.	Variety.	Date of—		Weight per bushel.[2]	Yield per acre.	
		Heading.[1]	Maturity.[1]		Grain.[3]	Straw.[4]
				Pounds.	*Bushels.*	*Pounds.*
1442	Kharkof	June 17	July 11	60.9	21.2	1,860
1583	Do	...do	...do	60.3	20.7	1,994
1571	Turkey	...do	...do	60.7	20.6	1,842
1558	Do	...do	...do	60.8	20.2	1,798
1437	Crimean	June 16	...do	60.4	19.7	1,924

[1] Average for 1910 and 1913 only.
[2] Average for 1908–1910 and 1913 only.
[3] Average for the entire period of six years, 1908–1913.
[4] Average for 1908, 1910, 1911, 1912, and 1913.

LEADING VARIETIES OF WINTER WHEAT.

The leading varieties of winter wheat at Newell are the Kharkof, Turkey, and Crimean. These varieties all have bearded heads, with white, hairless chaff, and hard red kernels. They all were imported from southern Russia, the Kharkof and Crimean by the United States Department of Agriculture and the Turkey by Russian immigrants and by commercial agencies. They are not distinguishable in appearance and differ only slightly in yield and in hardiness. It is probable that the Kharkof is slightly hardier than the Turkey or the Crimean, and for this reason it is to be preferred for sowing in western South Dakota.

DATE-OF-SEEDING TEST OF WINTER WHEAT.

A date-of-seeding test has been conducted each year at Newell with Turkey winter wheat, C. I. No. 3055. In this experiment, plats have been sown about the first and fifteenth of each month, from

August 15 to November 1. In addition, all the varieties were sown in the fall of 1907 on two dates, September 15 and October 5. In growing winter wheat in western South Dakota the date of seeding is considered to be next in importance to the selection of the variety and the preparation of the seed bed. The climatic conditions vary so much from year to year that it is difficult to determine this date accurately. The data here printed are believed to be suggestive only.

Table XIV shows the annual and average yields of winter wheat obtained on the Belle Fourche Experiment Farm from seeding on several dates during the years 1908 to 1913.

TABLE XIV.—*Annual and average yields of Turkey winter wheat in a date-of-seeding test on the Belle Fourche Experiment Farm, 1908, 1909, 1910, and 1913.*

Date of seeding.	Yield per acre (bushels).					
					Average.	
	1908	1909	1910	1913	1908–1910 and 1913.	1909, 1910, and 1913.
August 1	.....	.....	.....	29.2	.....	.....
August 16	.....	37.5	19.3	28.1	.....	28.6
September 1	23.0	39.0	8.3	28.1	24.6	25.1
September 16	20.3	40.5	22.0	(1)	.....	.....
October 1	24.3	43.0	(2)	28.1	23.8	20.7
October 16	24.7	42.0	13.3	21.4	25.3	25.6
November 1	25.5	37.3	13.2	16.3	23.1	22.3
November 16	.....	.....	.....	16.1	.....	.....

[1] Not sown because of severe drought. [2] Did not germinate.

As shown in Table XIV, the highest yield in 1908, 25.5 bushels per acre, was produced from the latest seeding. The difference in yield from the various dates of seeding was slight, except that the plat sown on September 16 yielded only 20.3 bushels per acre. The fall of 1907 was dry and the comparatively low winter survival and low yield of the earlier sown plats may have been due to the fact that growth was checked by the drought, and hence the plants did not go into the winter in good condition. In the varietal test, which was sown in duplicate on September 15 and October 5, six of the seven varieties produced higher yields from the later seeding.

The highest yield in 1909 was from the plat sown October 1, with gradual decreases toward the earlier and later seedings. Germination was prompt on the plat sown August 16, but the plants on the plats sown September 1, September 16, and October 1 did not emerge until October 23. Damage from the blowing of the soil prevented taking accurate notes on winterkilling.

In the fall of 1909 the plats were sown in duplicate with the exception of the first date. For some reason there was no germination on the plats sown October 1. The plants on one series of the plats sown on October 16 and November 1 were killed by the blowing of the soil

the following spring. The highest yield was obtained from the plats sown on September 16. The poor yield from the plat sown September 1 was due to low germination.

In the fall of 1910 the two sowings germinated at about the same time and the plants made a vigorous growth. The plat sown September 16 showed good germination but less growth than the two earlier seedings. The plants on the plats sown October 1 emerged but made little growth before winter, while in the plats sown October 16 and November 1 the seed germinated but the plants did not emerge. As there was little precipitation during the fall, winter, and spring, practically all of the plants were dead by May 1. There was a higher moisture content and better survival in the late-sown

FIG. 7.—Plats of winter wheat in the date-of-seeding test on the Belle Fourche Experiment Farm. (Photographed October 24, 1912.)

than in the early-sown plats. The fall of 1911 was so dry that the date-of-seeding as well as other tests with winter wheat were a complete failure.

In the fall of 1912 the test was replicated three times on fiftieth-acre plats instead of being sown on a single tenth-acre plat. An earlier and a later date of seeding, August 6 and November 16, respectively, were added to the test. The seeding of September 16 was not made, because the soil was so dry that germination could not be obtained. Good stands were secured from the plats sown on each date. A view of the plats on October 24 is shown in figure 7. The earliest date of seeding produced the highest yield, 29.2 bushels.

Because of the variations from year to year, the difference in average yields obtained from the various dates of seeding was not great. If the plats sown October 1, 1909, had not failed to germinate, that date probably would have given the highest average yield for the four years when crops were produced. The next highest yield

was from the plats sown October 16. For the three years, 1909, 1910, and 1913, the highest yield was from the August 16 seeding, with that of October 16 second.

The great variations in seasonal conditions make it difficult to decide the best date for seeding wheat in western South Dakota. If rains occur early and are fairly abundant, early seeding is probably best. It is not always possible to conserve sufficient moisture to insure germination; hence, it is not usually safe to sow in dry soil with the expectation of receiving sufficient rain for germination. The safest rule seems to be to have the ground ready for early seeding, so that the seed may be sown early or late as the conditions seem to indicate. The results obtained on the Belle Fourche Experiment Farm appear to show that sowing as late as November 1 will often give better yields than are obtained from spring wheat. Because the

FIG. 8.—The winter-wheat nursery on the Belle Fourche Experiment Farm in 1910.

current season's crop is often not thrashed and ready for sowing in August, it is desirable to carry over a supply of seed, so that the crop may be sown early if it appears to be desirable.

NURSERY EXPERIMENTS WITH WINTER WHEAT.

About 600 selected heads of Turkey, Kharkof, and Crimean wheats were sown in head rows in the fall of 1908. Practically all of these were sown in 60-foot rows the following year. As it seemed desirable to test the best of these selections in field plats as soon as possible, about 35 of them were sown in fiftieth-acre plats in the fall of 1910. Because of the extreme drought the next spring and summer no grain was produced. Enough seed was left from the 1909 crop, however, to sow in duplicate 60-foot rows in the fall of 1911. The seed did not germinate until the following spring, and the stand was then so thin that very low yields were obtained. The selections were

again sown in duplicate rows in the fall of 1912, while a few of which there was sufficient seed were sown in fiftieth-acre plats. A view of the winter-wheat nursery in 1910 is shown in figure 8.

The average yields of the selections in duplicate 60-foot rows in 1910, 1912, and 1913 varied from 32 to 65.8 ounces. Most of the selections yielded between 48 and 60 ounces. A few beardless races which were selected proved to be particularly high in yield. The average yield of all nine beardless races was 56.2 ounces, while the nine best bearded races produced an average yield of 56 ounces. The best beardless race, selection No. 343, produced an average yield of 65.8 ounces, while the best bearded race yielded 61.4 ounces.

The beardless races sown in fiftieth-acre plats in 1910 appeared to be fully as resistant to drought as any of the bearded races. There appeared to be little difference in hardiness between the bearded and beardless strains, not only at Newell but also at three other field stations in the northern Great Plains where they were tested. The grain is very similar to that of the Turkey and Kharkof wheats in quality and appearance. Whether these beardless strains originated from mechanical mixtures of some beardless fall variety, such as Ghirka Winter, or from accidental hybrids between a bearded hard winter wheat and a beardless winter wheat was not determined.

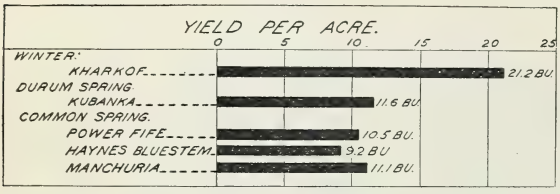

FIG. 9.—Diagram showing the average yields per acre, in bushels, of the best varieties of winter wheat and each group of spring wheat at the Belle Fourche Experiment Farm, for six years, 1908 to 1913, inclusive.

COMPARISON OF SPRING AND WINTER WHEATS.

A comparison of the yields of winter and spring wheat which have been obtained at Newell should be of interest and value. The annual and average yields of the best varieties of winter, of durum, and of common spring wheat are shown in Table XV. The average yields are also shown graphically in figure 9.

The yields of winter wheat in 1908 were slightly larger than those of the best durum wheats and exceeded by several bushels those of the spring common wheats. In 1909 the yields of winter wheat were nearly double those of the durum and more than double those of the spring common varieties. Again in 1910 the yields of winter wheat were double or more than double those of the spring varieties. In 1911 no yields of either spring or winter wheat were obtained, while in 1912 no grain was produced except by a few varieties of spring common wheat. In 1913 the yields of winter wheat were again about double those of durum and more than double those of the spring common wheats.

TABLE XV.—*Annual and average yields of the best varieties of winter and of durum and common spring wheats on the Belle Fourche Experiment Farm, 1908 to 1913, inclusive.*

Group and variety.	C. I. No.	Yield per acre (bushels).						
		1908	1909	1910	1911	1912	1913	Average.
Winter:								
Kharkof	1442	25.4	40.3	22.7	0	0	38.6	21.2
Spring durum:								
Kubanka	1516	23.8	22.6	5.3	0	0	19.1	11.8
Spring common:								
Manchuria	2492	16.2	16.0	12.8	0	4.5	17.1	11.1
Power	3025	18.5	17.3	10 6	0	0	16.6	10.5
Haynes	3020	18.3	13.8	9.0	0	0	14.1	9.2

To summarize: In three of the six years covered by the experiments the winter varieties have produced about double the yield obtained from the spring varieties. In one year the yield was only slightly larger and in two years practically all varieties of both spring and winter wheats were total failures. The average yield of the best winter variety for the six years was 21.2 bushels, while the average yield of the best durum variety was 11.8 bushels. Winter wheat is to be preferred to spring wheat, because the growing of a fall-sown grain allows a better distribution of labor throughout the year. Winter wheat also matures earlier and so is more likely to escape hailstorms, hot winds, and other unfavorable climatic conditions. On the other hand, sufficient moisture for germination is less likely to be available in the fall than in the spring, and there is also danger of damage to the crop from the blowing of the soil during the winter. Winterkilling has not been a factor of much importance in the experiments at Newell, nor is it likely to be if varieties of the Turkey group are grown. If a crop of winter wheat is lost because of the blowing of the soil, winterkilling, or other factors, there is still opportunity to sow the land to some spring crop. For these reasons the growing of winter rather than spring wheat is strongly recommended.

EXPERIMENTS WITH OATS.

The yields of oats which have been obtained at Newell have for the most part been unsatisfactory. In 1908, 1909, and 1913 fairly good yields were obtained, but in 1910 and 1912 the returns were less than the cost of production, while in 1911 a total failure was recorded.

The average yield of the best variety for the six years from 1908 to 1913 was only 19.4 bushels, which is less than the average yield of winter wheat for the same period. The yield of the best spring wheat for the six years was slightly less than 12 bushels to the acre, but the production in pounds is greater than that of oats and the value of the crop is also higher. For this reason the oat crop can not

be recommended to the farmer on the dry lands in western South Dakota. If oats are grown, only the very earliest varieties, such as Sixty-Day and Kherson, should be used.

The experiments with oats at Newell have included varietal tests and a test of rate of seeding with Kherson oats.

VARIETAL TEST OF OATS.

The varietal experiments with oats during the six years from 1908 to 1913 have included 16 varieties and races. Of these, eight may be classed as early, five as midseason, and three as late varieties. All the late varieties are side oats, while all the early and midseason varieties have open or spreading panicles. Only five of the 16 varieties have been grown in all of the six years. The annual and average yields of the 16 varieties and races are given in Table XVI.

TABLE XVI.—*Annual and average yields of 16 varieties and races of oats on the Belle Fourche Experiment Farm, 1908 to 1913, inclusive.*

Group and variety.	C. I. No.	Yield per acre (bushels).							
		1908	1909	1910	1911	1912	1913	Average.	
								6 years, 1908–1913.	4 years, 1910–1913.
Early varieties:									
Burt	293	.....	.....	.....	.....	6.0	22.4	.....	.....
Kherson	459	[a]47.5	[a]25.7	[a]15.0	0	6.2	21.9	19.3	10.8
Seventy-Five-Day	337	.....	.....	.....	.....	7.5	21.0	.....	.....
Sixty-Day	165	[a]46.6	25.0	15.6	0	6.6	22.7	19.4	11.2
Sixty-Day selection	(165–562)	.....	.....	.....	.....	6.2	.....	.....	.....
Do	(165–566)	.....	.....	.....	.....	7.1	23.3	.....	.....
Do	625	.....	.....	14.4	0	7.9	21.6	.....	11.0
Do	626	.....	.....	16.6	0	9.9	24.6	.....	12.8
Midseason varieties:									
Big Four	658	.....	32.0	3.6	0	14.1	19.5	.....	9.3
Canadian	444	38.8	21.3	4.4	0	10.4	18.5	15.6	8.3
Danish	441	36.1	.....	.....	.....	.....	.....	.....	.....
Great Dane	.....	.....	26.6	.....	.....	.....	.....	.....	.....
Swedish Select	134	38.1	28.4	2.3	0	9.2	15.2	15.5	6.7
Late varieties:									
White Russian	551	30.9	20.0	0	0	22.7	14.3	14.6	9.2
White Tartarian	300	30.9	22.8	0	0	.....	.....	.....	.....
Yellow Giant	342	19.4	17.5	0	0	.....	.....	.....	.....

[a] Average of two plats.

Table XVI shows that fairly good yields of oats were obtained from all varieties in 1908, when the seasonal rainfall was slightly above normal and the distribution of the rainfall was favorable. The low yield in 1909 was due in large measure to poor preparation of the seed bed and resulting poor germination and slow growth. Abundant rainfall favored the larger and later varieties, such as Big Four and Swedish Select, which may always be expected to yield more than the early varieties in particularly favorable years. In 1910 the conditions early in the season were exceptionally good, but the rainfall after the seed germinated was much below normal and consequently only the earliest varieties produced yields which were

worthy of consideration. In 1911 no yields were obtained from any of the varieties, because of the severe drought.

In 1912 there was little water stored in the soil, but the precipitation during the growing season was fairly favorable. On account of the dryness of the soil at seeding time the drill was run rather deeper than usual. Just after seeding a heavy rain caused the soil to pack and crust, so that the germination was low. This, in addition to the lack of stored water, caused the low yields which were obtained. The midseason and late varieties yielded better than the early varieties, for the reason that they were benefited by a heavy rain which fell early in July, too late to be of material help to the early varieties.

In 1913 the varietal test of oats was grown on land which produced a crop of corn in 1912. In all previous years the oats were grown on soil which had been fallowed. The corn land was not plowed but was disked and harrowed to make a good seed bed. The rainfall conditions were about normal and fair yields were obtained. As in previous years the earlier varieties produced the highest yields.

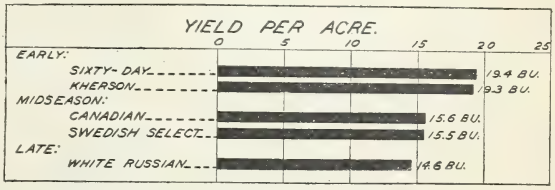

FIG. 10.—Diagram showing the average yields per acre, in bushels, of the leading varieties of oats at the Belle Fourche Experiment Farm, for six years, 1908 to 1913, inclusive.

In 1907 two plats of Boswell Winter oats, C. I. No. 480, were sown. Only a small percentage of the plants survived the winter, but these tillered so freely that a yield of 28.5 bushels per acre was obtained. This variety was again sown in 1908 and 1909, but winterkilled entirely each year.

LEADING VARIETIES OF OATS.

In Table XVII the average date of heading, date of ripening, weight per bushel, and yield per acre of grain and of straw are given for the five varieties which were grown during the entire period of six years. With the exception of the yield data, the averages are for five years (1908–1910, 1912, and 1913). The average yields of grain are shown graphically in figure 10.

The five varieties which have been grown for the entire six years at Newell, in the order of their average yield, are the Sixty-Day, Kherson, Canadian, Swedish Select, and White Russian. The pure-line selection of Sixty-Day, C. I. No. 626, which was added to the test in 1910, has given an average yield 1.6 bushels higher than the unselected Sixty-Day for the four years from 1910 to 1913.

The Sixty-Day and Kherson are very similar varieties, imported about 15 years ago from southern Russia. They are early in maturing,

ripening at Newell about July 20. The straw is short and the grains small and yellow. They are the best varieties for growing on the dry farms in the Belle Fourche section.

TABLE XVII.—*Average dates of heading and maturity, weight per bushel, and yields of five leading varieties of oats on the Belle Fourche Experiment Farm, 1908 to 1913, inclusive.*

Group and variety.	C. I. No.	Date of—		Weight per bushel.	Yield per acre.	
		Heading.	Maturity.		Grain.	Straw.
Early:				*Pounds.*	*Bushels.*	*Pounds.*
Kherson	459	June 27	July 20	30.8	19.3	800
Sixty-Day	165	June 26	July 17	30.9	19.4	720
Midseason:						
Canadian	444	July 8	July 29	34.5	15.6	1,080
Swedish Select	134	July 9	Aug. 2	28.2	15.5	930
Late:						
White Russian	551	July 18	Aug. 8	30.4	14.6	1,040

The Canadian is a medium-early oat which has averaged 4 bushels less than the Sixty-Day and Kherson at Newell for the six years. The yield of straw, however, is greater. The heads are large and spreading, and the kernels are white, broad, and very short. This variety matures about 10 days later than the Kherson.

The Swedish Select is extensively grown in the more humid regions to the eastward, but it is rather too late for sowing in western South Dakota. This is a white oat with kernels of medium length, rather broad, and usually bearing a strong, black awn. It matures about five days later than the Canadian and about two weeks later than the Kherson and Sixty-Day.

The Big Four is quite similar to the Swedish Select except that the awns are few and weak. It has produced rather better yields than the Swedish Select at Newell each year since 1909, when it was added to the test. For the four years from 1910 to 1913 this variety was exceeded in average yield only by the Kherson and Sixty-Day and by two pure-line selections of the latter variety. It is apparently the best of the midseason and late varieties which have been included in the test.

White Russian is a late side oat, with long and rather slender white kernels. The average yield of this variety for the six years is slightly lower than that of the Swedish Select and Canadian. It matures about one week later than the Swedish Select and about three weeks later than the Kherson and Sixty-Day. It can not be recommended for growing in the Great Plains.

RATE-OF-SEEDING TEST OF OATS.

A rate-of-seeding test with oats was conducted on the Belle Fourche Experiment Farm in 1909, 1910, 1912, and 1913. In 1909 and 1910 the Kherson and in 1912 and 1913 the Sixty-Day varieties were

used. Plats were sown at the rates of 4, 6, 8, and 10 pecks each year. In addition, the 2-peck rate was used in 1909 and the 12-peck in 1910, 1912, and 1913. The test was conducted on fallow land in 1909, 1910, and 1912, while in 1913 it was on land which produced corn the previous year. In 1909 and 1910 single tenth-acre plats were sown at each rate. In 1912 and 1913 the test was replicated, three fiftieth-acre plats being sown at each rate.

Table XVIII shows the annual and average yields obtained in the rate-of-seeding test with oats in 1909, 1910, 1912, and 1913.

TABLE XVIII.—*Annual and average yields of oats in a rate-of-seeding test on the Belle Fourche Experiment Farm in 1909, 1910, 1912, and 1913.*

[In 1909 and 1910 the variety used was the Kherson, C. I. No. 459. In 1912 and 1913 the Sixty-Day variety, C. I. No. 165, was used.]

Rate per acre.	Yield per acre (bushels).				
	1909	1910	1912	1913	Average.
2 pecks	25.9				
4 pecks	30.2	11.9	8.9	28.2	19.8
6 pecks	32.8	12.5	10.3	27.3	20.7
8 pecks	35.3	10.3	9.2	27.3	20.5
10 pecks	35.9	4.1	9.7	28.1	19.5
12 pecks		3.4	9.1	28.2	

In 1909, which was a favorable year, the higher rates of seeding gave the better yields, though the differences between the 6, 8, and 10 peck rates were small. In 1910, a very dry year, the best yields were obtained from the 4-peck and 6-peck rates. The yields obtained from the 10-peck and 12-peck rates of seeding little more than equaled the quantity of seed which was sown. In 1912, another dry year, there was little variation in the yields which were obtained, though the 6-peck rate produced slightly more than any of the others. In 1913, a favorable year, the yields obtained from all the rates of seeding were practically the same.

The average yield for the four years from the 4, 6, 8, and 10 peck rates shows little variation, though the figures favor slightly the 6-peck rate. The thickly sown plats ripened earlier than those sown at the lower rates, while the yield of straw was usually less. In very dry years thin seeding is to be preferred. On the other hand, in favorable seasons fully as good yields and slightly earlier maturity will be obtained from thick seeding. It seems probable that 6 pecks is about the best rate for early varieties, such as the Sixty-Day and Kherson.

NURSERY EXPERIMENTS WITH OATS.

About 100 heads each of the Sixty-Day and Kherson oats were selected in 1908 and grown in head rows in 1909. In addition a number of selections of the Sixty-Day made at the Highmore sub-

station, Highmore, S. Dak., were grown in head rows in 1908 and in duplicate 60-foot rows in 1909. The most promising of the Highmore selections were grown in duplicate fiftieth-acre plats in 1910, while the remainder of these and the progeny of the 1909 head rows were grown in 60-foot rows. In 1912 and 1913 the best of these selections were grown either in plats or in replicated 60-foot rows.

Two of these selections, Nos. 562 and 566, were grown in the regular varietal test in 1912, where they produced about the same yields as the unselected Sixty-Day. Selection No. 566 was again grown in 1913, when it slightly exceeded in yield the parent variety. None of the selections which have been made at Newell from the Sixty-Day and Kherson varieties appears to be particularly better than the original unselected stocks.

EXPERIMENTS WITH BARLEY.

Barley is quite an important crop in the northern Great Plains, because of its early maturity, its comparatively low water requirement, and the feeding and market value of the grain. The varietal test at Newell has included the principal varieties that have given good results elsewhere in the northern Great Plains. On the whole, the results which have been obtained are decidedly disappointing. From the results here reported, barley can not be recommended for the Belle Fourche section.

VARIETAL TEST OF BARLEY.

The varietal test has included five strains of 6-rowed hulled, two of 6-rowed naked, and five of 2-rowed hulled barley during the six years. Only two of the varieties were grown in all of the six years, while six were grown in the five years from 1909 to 1913. The annual and average yields of all the varieties from 1908 to 1913 are shown in Table XIX.

In 1908 two lots of Hanna barley, one of Manchuria, and two of Nepal were grown. The highest yields were obtained from the Hanna, a 2-rowed hulled variety. The yields from both the 2-rowed and 6-rowed hulled varieties were fairly satisfactory. Two varieties of winter barley which were sown in the fall of 1907 entirely winterkilled.

In 1909 four 2-rowed hulled, three 6-rowed hulled, and two 6-rowed naked varieties were grown. The hulled varieties yielded from 17.3 to 23.8 bushels per acre, while the naked varieties yielded about 9 bushels each. The highest yield was again obtained from the Hanna, C. I. No. 24.

The same varieties were grown in 1910. Because of the extreme drought only the very earliest varieties matured grain, and the crop obtained even from these was very small. The Odessa, an early

6-rowed variety, produced the highest yield, 8.1 bushels. The yields obtained from the 6-rowed naked and the 2-rowed hulled varieties were not sufficient to pay for the cost of harvesting. All the varieties were a total failure in 1911.

TABLE XIX.—*Annual and average yields of 12 varieties of barley on the Belle Fourche Experiment Farm, 1908 to 1913, inclusive.*

Group and variety.	C. I. No.	Yield per acre (bushels).								
		1908	1909	1910	1911	1912	1913	Average.		
								6 years, 1908–1913.	5 years, 1909–1913.	2 years, 1912–1913.
Six-rowed hulled:										
Gatami	575	.....	.....	.....	.....	18.3	8.2	.....	.....	13.2
Manchuria (Minn. No. 105)	354	.....	.....	.....	.....	7.6	6.6	.....	.....	.....
Manchuria (Minn. No. 6)	638	.....	19.8	5.2	0	8.1	8.0	.....	8.2	8.0
Manchuria	643	26.0	17.3	4.3	0	7.2	.....	.....	.....	.....
Odessa	182	.....	22.1	8.1	0	9.8	8.7	.....	9.7	9.2
Six-rowed naked:										
Nepal (White Hull-less)	262	16.3	9.6	2.5	0	.....	.....	.....	.....	.....
Do	.....	12.0	9.0	1.7	0	10.7	8.9	7.0	6.1	9.8
Two-rowed hulled:										
Chevalier II	530	.....	22.1	0	0	0	6.8	.....	5.8	3.4
Hanna	24	29.0	[a]23.8	[a]1.0	0	0	10.7	10.7	7.1	5.3
Do	203	27.9	21.4	1.4	0	0	.....	.....	.....	.....
Hannchen	531	.....	19.2	3.1	0	0	12.7	.....	7.0	6.3
White Smyrna (Ouchac)	658	.....	.....	.....	.....	10.7	14.3	.....	.....	12.5

[a] Average of 2 plats.

In 1912 ten of the twelve varieties which were included in the test were grown in fiftieth-acre plats replicated five times. The other two varieties were grown in single plats, as there was not sufficient seed for the replications. The soil in which the test was conducted had in previous seasons appeared to be very uniform, but the growth and yield of the barley varieties in 1912 showed great variation. This was perhaps due to the drifting of the snow on the plats during the previous winter, as the rainfall was extremely low in 1912 and slight differences in moisture content were likely to cause considerable variations in yield. Many of the plats produced no grain and others matured seed only along the borders. The only variety of which all plats were harvested was the Gatami, an early black 6-rowed variety, which was grown for the first time at Newell in 1912. The yield of this variety was 18.3 bushels to the acre.

In 1913 the barley varieties were grown on land upon which a small crop of spring wheat was produced the previous year. The soil was in excellent condition at the time of seeding, and germination and growth were prompt and vigorous. The rainfall during June and July was slight, so that all the varieties were injured by drought. A hailstorm which occurred just as the earlier varieties were heading severely injured the Gatami and did some damage to the Manchuria and Odessa varieties. The highest yields in 1913 were produced by

the 2-rowed barleys, though it is probable that the Gatami and the other 6-rowed varieties would have yielded more than any of the 2-rowed barleys if they had not been injured by hail.

Only the Hanna, C. I. No. 24, and the Nepal have been grown for the entire six years. The average yield of the Hanna for that period was 10.7 bushels, and of the Nepal, 7 bushels. Six varieties have been grown for the five years from 1909 to 1913. Of these, the highest yield, 9.7 bushels, was produced by the Odessa, a medium-early 6-rowed variety. The Manchuria (Minnesota No. 6) averaged 8.2 bushels for this period and the Hanna and Hannchen about 7 bushels each. The average yields of these varieties are shown graphically in figure 11.

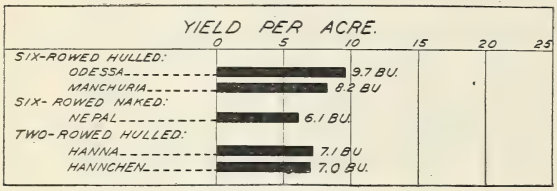

FIG. 11.—Diagram showing the average yields per acre, in bushels, of the leading varieties of barley at the Belle Fourche Experiment Farm, for five years, 1909 to 1913, inclusive.

LEADING VARIETIES OF BARLEY.

The average date of heading and of maturity, weight per bushel, and the yield of grain and of straw for the leading varieties of barley grown at Newell are given in Table XX.

TABLE XX.—*Average dates of heading and of maturity, weight per bushel, and yields of the seven leading varieties of barley on the Belle Fourche Experiment Farm, 1909 to 1913, inclusive.*

Group and variety.	C. I. No.	Date of—		Weight per bushel.	Yield per acre.	
		Heading.	Maturity.		Grain.	Straw.
				Lbs.	*Bush.*	*Lbs.*
Six-rowed hulled:						
Gatami	575	June 25 [a]	July 14 [a]	[a] 45.1	[a] 13.2	[a] 870
Odessa	182	June 26 [b]	...do [b]	[b] 45.5	9.7	760
Manchuria (Minn. No. 6)	638	June 30 [b]	July 18 [b]	[b] 44.3	8.2	600
Two-rowed hulled:						
White Smyrna (Ouchac)	658	.....	July 15 [a]	[a] 42.4	[a] 12.5	[a] 940
Hanna	24	July 3 [c]	July 22 [d]	[d] 46.9	7.1	750
Hannchen	531	...do [c]	July 18 [d]	[d] 46.9	7.0	640
Six-rowed naked:						
Nepal	.....	June 28 [b]	July 20 [b]	[b] 58.6	6.1	590

[a] Two-year average, 1912 and 1913.
[b] Four-year average, 1909, 1910, 1912, and 1913.
[c] 1909 only; heads not fully exserted in 1910, 1912, and 1913.
[d] Three-year average, 1909, 1910, and 1913; failure in 1911 and 1912

The Odessa, C. I. No. 182, a 6-rowed bearded hulled barley, has given the highest average yield at Newell for the five years from 1909 to 1913. This variety is early in maturing, ripening at Newell about a week before the Hanna and four or five days earlier than the Manchuria. It was introduced from southern Russia, where it is grown in the same region as the Sixty-Day and Kherson oats. It is recommended as one of the best varieties of barley for western South Dakota.

The Gatami, C. I. No. 575, has been grown at Newell only in 1912 and 1913. In 1912 it yielded 18.3 bushels to the acre, nearly double the yield obtained from any other variety. In 1913 it was exceeded in yield by several varieties. Its average yield for the two years is 4 bushels greater than that of the Odessa for the same period. The Gatami matures a little earlier than the Odessa, and for that reason is to be preferred to it. The grain, however, is black and hence is lower in market value than the Odessa and other light-colored barleys.

The Manchuria (Minnesota No. 6), C. I. No. 638, is the 6-rowed bearded barley commonly grown in Minnesota and Wisconsin. It is several days later in maturing than the Gatami and Odessa, and its average yield for the five years from 1909 to 1913 is $1\frac{1}{2}$ bushels less than that of the Odessa. It can not be recommended for western South Dakota.

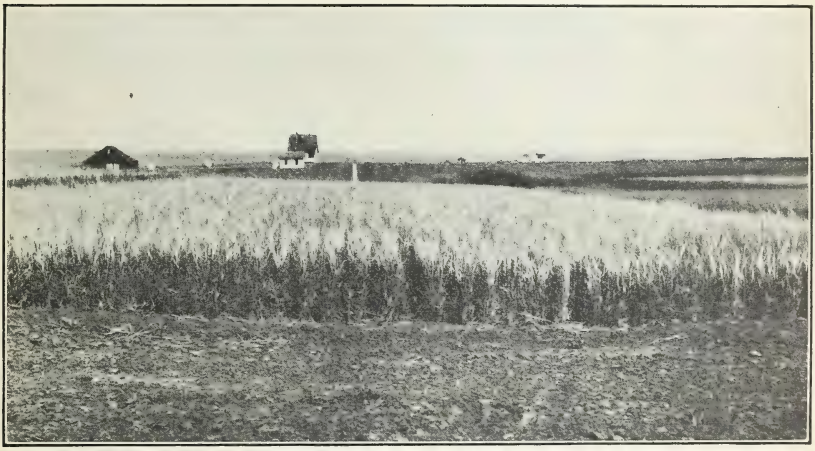

FIG. 12.—Plat of Hanna barley on the Belle Fourche Experiment Farm, 1910.

The Hanna and Hannchen are 2-rowed bearded hulled barleys which yielded well in 1909 and 1913. The Hanna was also grown in 1908, when it produced the highest yield of any variety included in the test. The Hanna and Hannchen matured no grain in 1911 and 1912 and only a very small crop in 1910, so that their average yields for the five years from 1909 to 1913 were only 7.1 and 7 bushels per acre, respectively. This is more than $2\frac{1}{2}$ bushels less than the average yield of the Odessa for the same period. These 2-rowed barleys are a week to ten days later in maturing than the Odessa and the Gatami, and ordinarily they mature later than the Manchuria. At Newell they have usually ripened prematurely, so that the length of their growing season there is below the normal. A field of Hanna barley on the experiment farm in 1910 is shown in figure 12.

The White Smyrna, C. I. No. 658, an early 2-rowed barley, was grown at Newell only in 1912 and 1913. In 1912 it was exceeded in yield only by the Gatami, while in 1913 it produced the highest yield of any variety in the test. The average yield for the two years is 12.5 bushels, only 0.7 bushel less than that of Gatami and higher than that of any other variety. If a 2-rowed variety of barley is to be grown in western South Dakota, it is probable that the White Smyrna or some similar one should be selected.

The yields obtained from the Nepal (White Hull-less), a 6-rowed naked variety, have been less than those from any of the hulled varieties, except in 1912 and 1913. In these years the Nepal produced less than the best hulled varieties.

EXPERIMENTS WITH MINOR CEREALS.

RYE.

Winter rye has been grown in field plats at Newell for only one year, 1913. Three plats produced an average yield of 5.3 bushels, as compared with a yield of 38.8 bushels of Kharkof winter wheat on a near-by plat The low yield of the rye was in part due to damage from a hailstorm, which occurred after the rye headed but before the wheat was far enough advanced to be injured. Another reason for the low yield was that a large percentage of the florets failed to set seed, probably because the pollen was injured by high temperatures, low humidity, or some other unfavorable climatic condition.

EMMER.

Spring emmer, C. I. No. 1524, has been grown each year with the series of barley varieties, as it was considered that emmer is comparable to barley as a feed grain. The yields obtained were as follows: 1908, 31.8 bushels; 1909, 21.7 bushels; 1910, 0.3 bushel; and 1913, 11.1 bushels. No yields were produced in 1911 and 1912. The average yield for the six years was 10.8 bushels, while the yield of Hanna barley for the same period was 10.7 bushels. For the five years from 1909 to 1913 the average yield was only 6.6 bushels, as compared with 9.7 bushels for the Odessa barley. For the same period, Sixty-Day oats yielded 14.0 bushels and Kubanka durum wheat 9.4 bushels. These yields are equivalent to 211 pounds of emmer, 466 of barley, 448 of oats, and 564 of wheat.

Black Winter emmer, C. I. No. 2337, was sown in the fall of 1908. It is estimated that only 1 per cent of the plants survived the winter. This crop was not grown again until the fall of 1912, when a plat of Buffum Improved winter emmer, C. I. No. 3331, was sown. This variety yielded 1,035 pounds of grain, as compared with 2,130 pounds of winter wheat on a near-by plat.

The few tests of emmer which have been made at Newell indicate that the crop is not one which can be recommended for that section.

EXPERIMENTS WITH FLAX.

VARIETAL TEST.

A varietal test of flax was begun at Newell in 1912, when nine varieties were grown. Only five of these were grown in 1913. In 1912 flax was grown on land which was fallow the previous year and in 1913 on land which produced a crop of small grain in 1912. The annual and average yields of grain and of straw for the five varieties are shown in Table XXI.

TABLE XXI.—*Annual and average yields of five varieties of flax on the Belle Fourche Experiment Farm in 1912 and 1913.*

C. I. No.	Variety.	1912		1913		Average.	
		Grain.	Straw.	Grain.	Straw.	Grain.	Straw.
		Bushels.	*Pounds.*	*Bushels.*	*Pounds.*	*Bushels.*	*Pounds.*
12	Primost (Minn. No. 25)	9.1	880	4.8	910	7.0	895
19	Russian (N. Dak. No. 155)	8.9	730	5.2	830	7.1	780
7	Smyrna	11.4	880	2.8	710	7.1	795
1	Select Russian (N. Dak. No. 608)	10.6	1,130	3.3	630	7.0	880
3	Select Russian (N. Dak. No. 1215)	11.2	940	5.6	910	8.4	925

The highest average yield of flax obtained on the Belle Fourche Experiment Farm, 8.4 bushels per acre, as shown in Table XXI, was produced by the Select Russian, C. I. No. 3. This variety produced the highest yield in 1913 and was only slightly exceeded by one other variety in 1912. C. I. No. 3 is a pedigreed strain from the North Dakota Agricultural Experiment Station, being North Dakota No. 1215. The yields of the four other varieties which were tested both years were practically the same, being 1.3 or 1.4 bushels less than that of C. I. No. 3.

DATE-OF-SEEDING TEST OF FLAX.

A date-of-seeding test with Primost (Minnesota No. 25) flax was conducted at Newell in 1912 and 1913. Fiftieth-acre plats replicated three times were sown on each of two dates, May 15 and June 1, in 1912, and on three dates, May 2, May 23, and June 9, in 1913. The yields of grain and of straw and the weight per bushel of the grain from the various dates of seeding are shown in Table XXII.

The highest yield in 1912 was obtained from the later date of seeding, June 1. The increase in yield over the sowing made May 15 was about 25 per cent. The earlier sown plats were injured by drought to a greater extent than the plats sown on June 1. In 1913 this condition was reversed. The highest yield was produced from the earliest sown plats and the injury from drought increased with the later dates of seeding. It is probable that the best results will be obtained in western South Dakota if flax is sown at the earliest date when good germination and growth may be expected.

TABLE XXII.— *Yields of flax and weight of seed per bushel in a date-of-seeding test on the Belle Fourche Experiment Farm in 1912 and 1913.*

Date of seeding.	Yield.		Weight of seed per bushel.
	Grain.	Straw.	
1912.	*Bushels.*	*Pounds.*	*Pounds.*
May 15	8.3	1,020	55.0
June 1	10.6	1,860	54.3
1913.			
May 2	7.7	1,110	54.8
May 23	4.8	830	55.0
June 9	3.0	530	53.7

SUMMARY.

The experiments here reported were conducted on unirrigated land on the Belle Fourche Reclamation Project at Newell, S. Dak., from 1908 to 1913.

The results obtained at Newell are believed to be applicable in general to western South Dakota, northeastern Wyoming, and southeastern Montana.

The experiments were conducted on a heavy, impervious clay soil known as Pierre clay. This soil is quite typical of the locality.

The average precipitation during the six years was 13.41 inches. The average precipitation during the growing season for small grains, March to July, inclusive, was 7.76 inches. The minimum precipitation for the growing season and for the year was recorded in 1911.

On the average, satisfactory yields were obtained from winter wheat and fairly good yields from spring wheat. The returns from spring oats, barley, and emmer and from winter rye and emmer have not been sufficient to make these crops profitable. Total or almost total failures of all crops were recorded in 1911 and 1912.

The best average yields of spring wheat have been obtained from the durum varieties, Kubanka and Arnautka. Of the spring common wheats, the best variety to grow appears to be the Power Fife.

The best rate of seeding for durum wheat is from 4 to 5 pecks to the acre and for spring common wheat from 3 to 4 pecks.

The best varieties of winter wheat for western South Dakota are the Kharkof, Turkey, and Crimean. These are very similar varieties, which differ only slightly in value.

Experiments to determine the best date of seeding for winter wheat have failed to show any definite results. In general, the date of seeding must be determined by the seasonal conditions. Medium early seeding is to be preferred if there is sufficient moisture to insure germination.

It is much better to grow winter wheat than spring wheat in the Belle Fourche section. The average yield of Kharkof winter wheat

for the six years was 21.2 bushels, of the best durum 11.8 bushels, and of the best spring common 11.1 bushels.

The best average yields of oats for the six years were obtained from the Sixty-Day and Kherson varieties. The returns from this crop were much lower than from winter wheat and slightly lower than from spring wheat.

The best rate of seeding for small-kerneled early varieties of oats, such as the Sixty-Day and Kherson, is about 6 pecks to the acre.

The returns from barley were even less satisfactory than those from oats. The best average yield for the six years was only 10.7 bushels, and for the five years from 1909 to 1913, only 9.7 bushels. The most satisfactory varieties are those which mature early, such as the 6-rowed varieties, Gatami and Odessa, and the 2-rowed variety, White Smyrna.

The yields obtained from winter rye and from winter and spring emmer have been much lower than those from the other cereals. These crops can not now be recommended for western South Dakota.

The best yield from flax in a 2-year test was obtained from the Select Russian variety. It is probable that the best results will be obtained if this crop is sown as early as good germination and growth may be expected.

The following varieties are recommended for the Belle Fourche section:

Winter wheat.—Kharkof, Turkey, Crimean.
Spring wheat.—Kubanka durum, Arnautka durum, Power Fife, Marquis.
Oats.—Sixty-Day, Kherson.
Barley.—Odessa, Gatami, White Smyrna.

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